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Exam AT 329, 2006

Q3, GPR

(Ground Penetrating Radar)

Proposed solutions.

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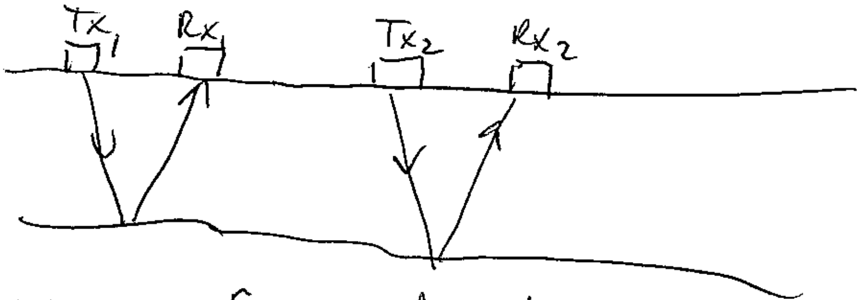
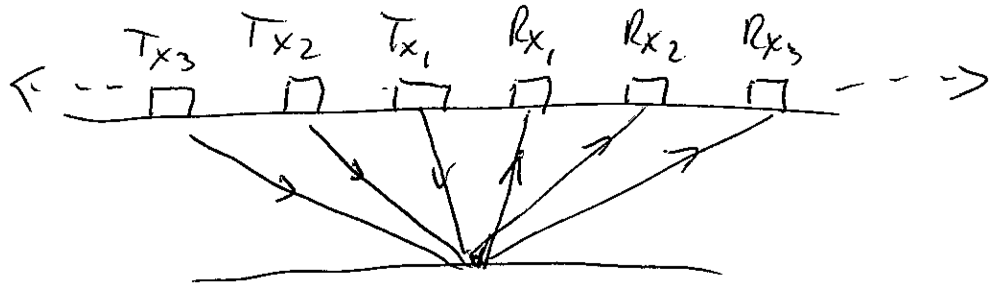
Q3 (1)

(a) ① Reflection mode



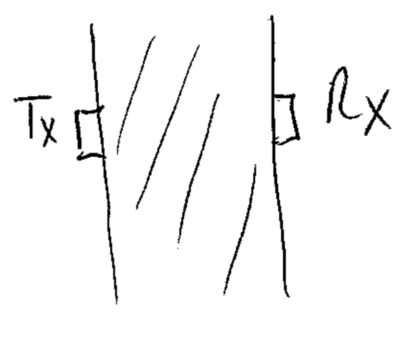
Profiling for lateral mapping.

② Common Midpoint Mode (CMP)



Used in velocity analysis

③ Trans illumination



Look through a material, Both sides or in two boreholes.

Describe the material in between.

Q3 b

σ : electrical conductivity

μ_r : magnetic permittivity

$\mu_r = 1 + \chi$, χ = magnetic susceptibility

ε_r : dielectrical constant or dielectic permittivity

ε_r controls the GPR reflections

Q3 c

Trace : Reflected signal as function of time

Sampling interval : Time distance between each sampling

Time window : How long time we have sampled data

Number of stacks : Repeated sampling in time

Q_3 c cont.

Number of points pr. trace, x:

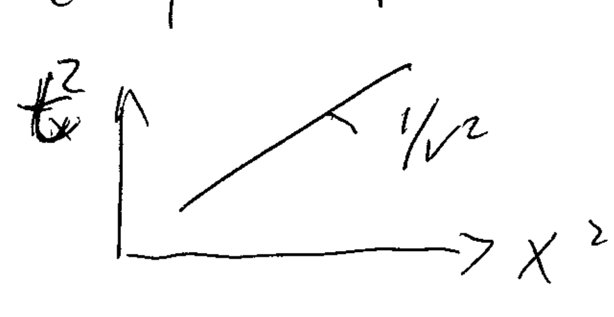
$$x = \frac{1800\ ns}{1600\ ps} = \frac{1800 \cdot 10^{-9}\ s}{1600 \cdot 10^{-12}\ s} = 1125\ \text{Points/trace}$$

With 4 stacks: $1125 \times 4 = 4500$

Alltogether: 4500 pulses transmitted

Q_3 d

1. Use a rod to measure the depth to a reflector (bottom of snow, bottom of peat).
2. Look at an hyperbola, calculate t^2 for different x^2, plot t^2 as f.o. x^2
   slope $= 1/v^2$



3. Use CMP gather, correct for Normal Move Out (NMO), details see Q3f

<u>Q3 d cont.</u>

(4) Reflections from point reflectors apear as hyperbolas in the GPR-sections. With modern software we can fit a theoretical hyperbole to these, and the shape will give the velocity.

(5) Empirical values. (formulas)
For dry snow, different formulas

$$\varepsilon_{r_{ds}} = 1.0 + 1.9 \cdot \rho_s \quad \rho_s \leq 0.5\ g/cm^3$$

$$\varepsilon_{r_{ds}} = 0.51 + 2.88\ \rho_s \quad \rho_s \geq 0.5\ g/cm^3$$

Measure snow density (ρ_s), calculate $\varepsilon_{r_{ds}}$ and then calculate

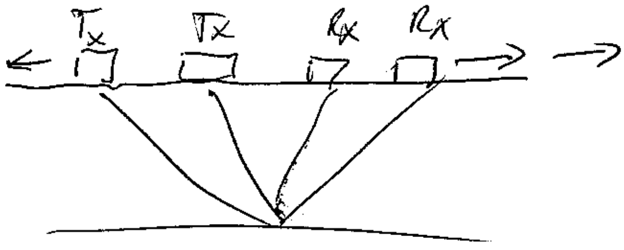
$$v_{ds} \approx \frac{c}{\sqrt{\varepsilon_{r_{ds}}}}$$

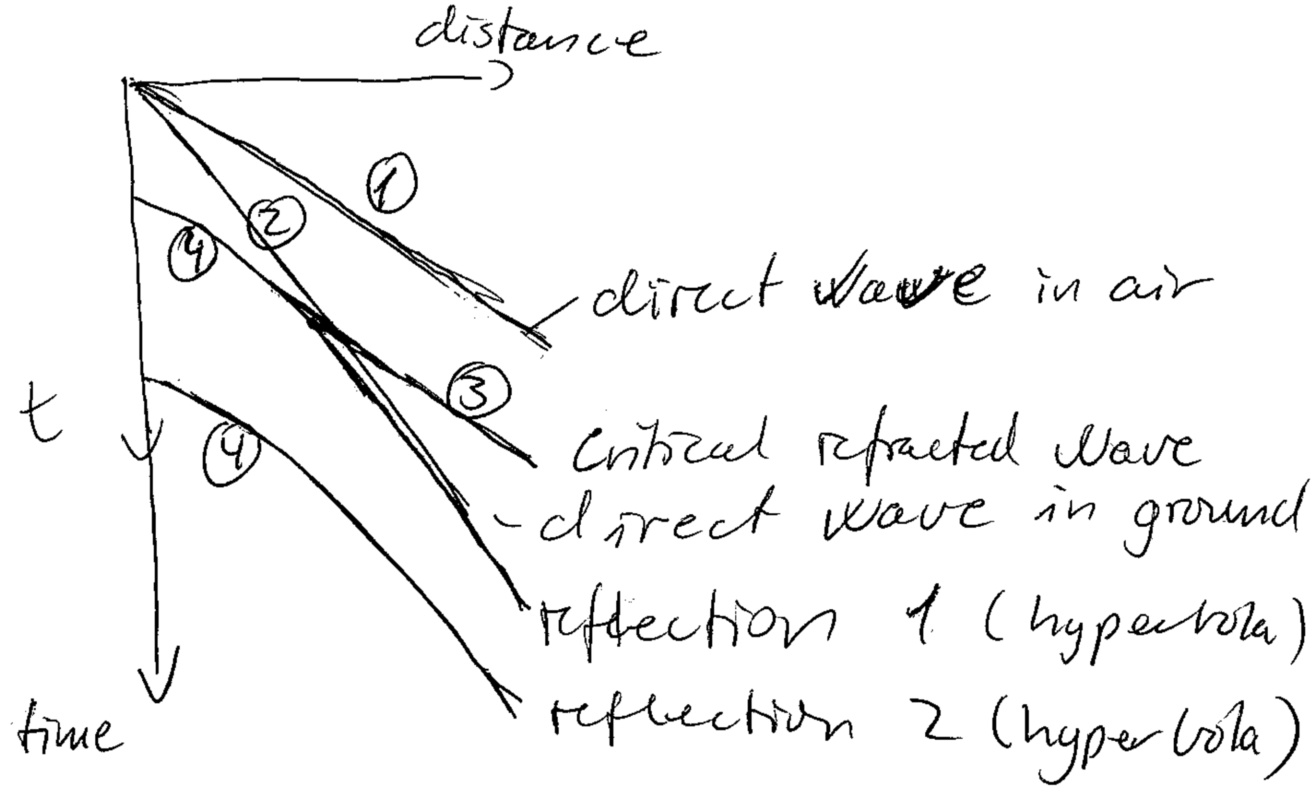
(5)

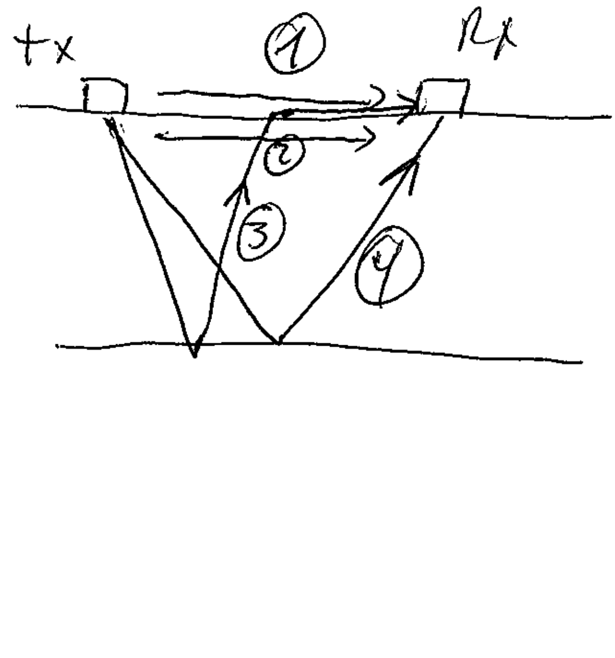
Q3e

Tx and Rx stepwise in both directions!

CMP gather

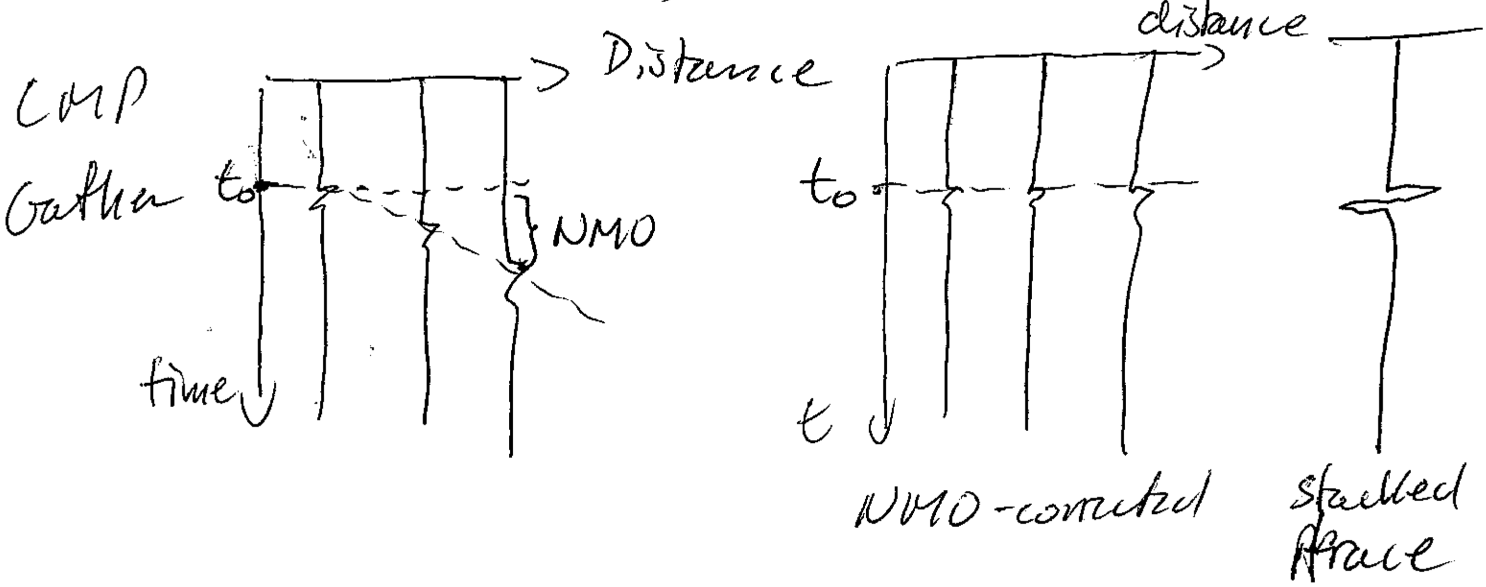






Q 3d

Use a CMP-gather, do NMO-correction $NMO \approx \frac{x^2}{2v^2t_0}$. If we use the right velocity v, all reflections will be corrected to the same time. (straight line).



Correct velocity will give all reflections at the same time to ($t_x = t_0$). Stacking of all traces (summation) will give max amplitude when we have right velocity. Wrong velocity give adjusted reflections at different times at each trace.

Q3g

$$\Delta t \approx \frac{x^2}{2v^2 t_0}$$

$$v^2 = \frac{x^2}{2t_0 \cdot \Delta t}$$

$$v = \sqrt{\frac{x^2}{2t_0 \Delta t}} \qquad \Delta t = t_x - t_0$$

$x = 10$ $\quad V_{10} = \sqrt{\frac{10^2}{2 \cdot 200 (209 - 200)}} = 0.167$ m/ms

$x = 20$ $\quad V_{20} = \sqrt{\frac{20^2}{2 \cdot 200 (235 - 200)}} = 0.169$ m/ms

$x = 30$ $\quad V_{30} \sqrt{\frac{30^2}{2 \cdot 200 (278 - 200)}} = 0.1698$ m/ms

Average velocity = 0.169 m/ms

This could be ice (cold).

Q3 h

Exact time function:

$$t^2 = t_0^2 + \frac{x^2}{v^2}$$

$$t = \sqrt{t_0^2 + \frac{x^2}{v^2}}$$

$$t_{10} = \sqrt{200^2 + \frac{10^2}{0.169^2}} = 208.6\ ns; \quad \underline{99.8\%}$$

$$t_{20} = \sqrt{200^2 + \frac{20^2}{0.169^2}} = 232.6\ ns; \quad \underline{99\%}$$

$$t_{30} = \sqrt{200^2 + \frac{30^2}{0.169^2}} = 267.8\ ns; \quad \underline{96.3\%}$$

Explanation:

NMO is a simplified expression which is valid only if $X \ll 2Z$.

In this case, $t_0 = 200\ ns$, $v = 0.169\ m/ns$

$\Rightarrow 2Z = 200\ ns \cdot 0.169\ m/s = \underline{33.8\ m}$

$X \approx 2Z$, expression for <u>NMO not valid</u> when $X = 30\ m$, hardly not for $x = 20\ m$

Q3 a

(9)

(1) target in detection range?

$$d_{max} < \frac{35}{\sigma}$$

High conductivity ⇒ high attenuation

Does the radar wave go as deep as the target?

(2) Has the target high enougth contrast in dielectricity

$$P_r = \left| \frac{\sqrt{\varepsilon_{r\,Host}} - \sqrt{\varepsilon_{r\,target}}}{\sqrt{\varepsilon_{r\,Host}} + \sqrt{\varepsilon_{r\,target}}} \right|^2 > 0{,}01$$

(3) Something that precludes use of GPR

- radio transmitters
- tunnel lined with metal mesh
- –"– –"– –"– metal reinforced concreate

Radio transmitter give noise that can't be filtered out. (same frequency as signal).

Metal mesh, reinforced concreate ⇒ high conductivity ⇒ great attenuation.